

Terrestrial Heterotardigrada (Tardigrada) from Korea

Kim, Hoon Soon and Moon, Seung Nyeo

(Department of Zoology, College of Natural Sciences, Seoul National University, Seoul 151-742,
Republic of Korea)

韓國產 陸上 異緩步類 (Heterotardigrada, Tardigrada)

金 熏 洙 · 文 升 汝
(서울대학교 自然科學大學 動物學科)

적 요

한국 육상성 異緩步動物 (Heterotardigrada, Tardigrada) 상을 조사하기 위하여 1985년 4월부터 1987년 10월까지 전국 각 지역에서 채집된 이끼와 지의류를 조사한 결과, 이 중 14개 지소에서 표본들을 얻었고 동정한 결과 10종의 육상 異緩步類가 확인되었다. 이들에 대한 그림과 아울러 기재 또는 특기 (remarks) 를 기록하였는 바 2종을 제외한 나머지 8종은 한국에서 처음으로 보고되는 종들이다.

Key words: Taxonomy, Terrestrial Heterotardigrada, Korea.

INTRODUCTION

There has been little work done on the fauna of the Korean tardigrades so far. Marcus (1936), in his monograph on Tardigrada, included some specimens of *Echiniscus baius* Marcus, 1928 from Korea but its localities in Korea were not specified. On the other hand, Ramazzotti (1983), in his monograph, recorded North Korea as one of the collection localities of *Echiniscus montanus* Iharos, 1982. Except that only two above species of Heterotardigrada were recorded to distribute in Korea by the foreign investigators, tardigrades remain still unknown in Korea, and there are no previous

published records on them. For the present taxonomical study on the terrestrial Heterotardigrada from Korea, samplings from different sites in South Korea were conducted in 1985-1987. As the result of the investigation, ten species of Heterotardigrada were identified and fully described with figures.

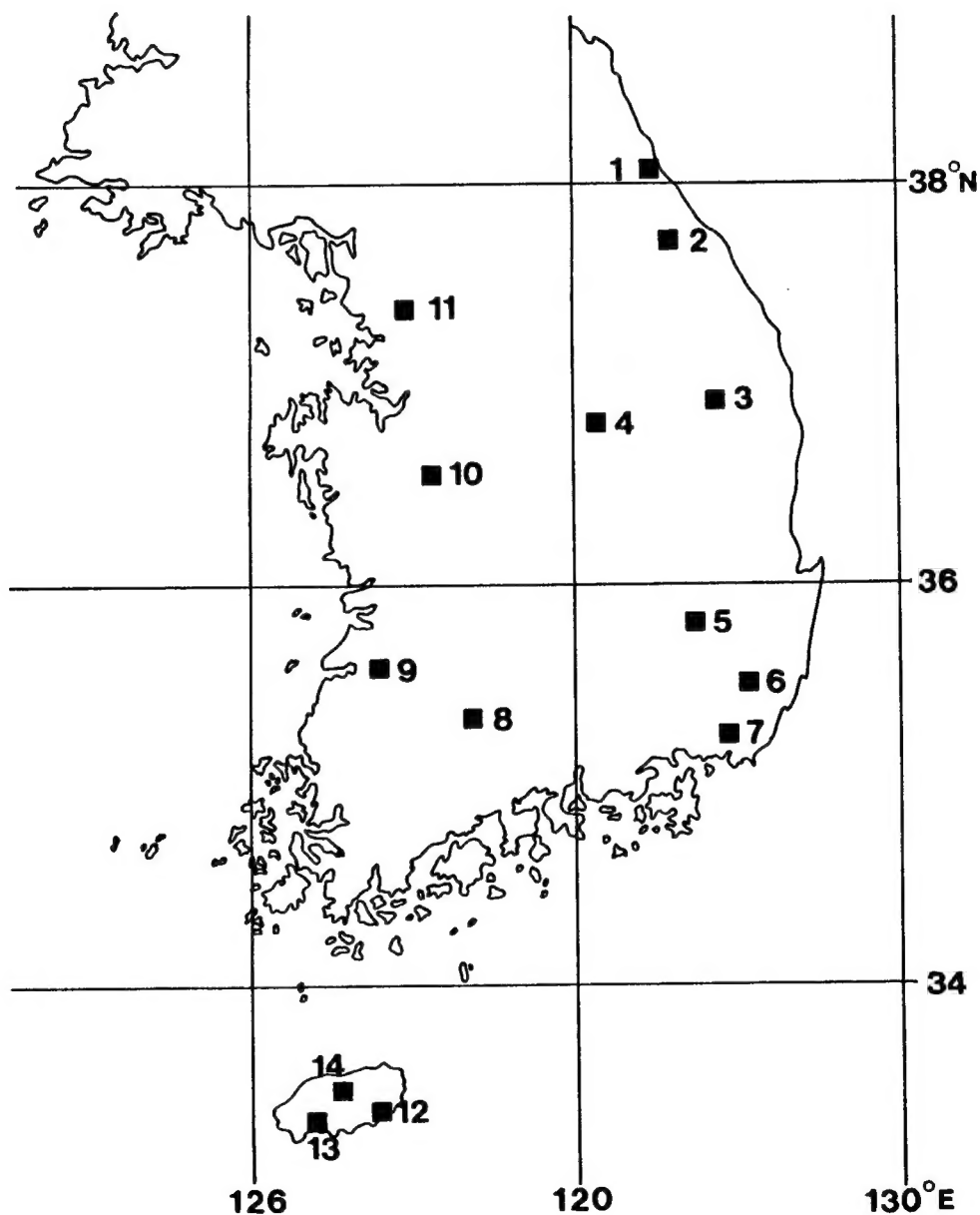


Fig. 1. A map showing the collection sites. 1, Sörksan; 2, Odaesan; 3, Ponghwa; 4, Woraksan; 5, P'algongsan ; 6, Yangsan; 7, Shin'ōsan; 8, Chirisan; 9, Chōng-up, Chōngju; 10, Kongju; 11, Seoul Nat'l Univ; 12, Sōgwip'o; 13, Taep'o; 14, Hallasan.

MATERIALS AND METHODS

The materials examined in this study consist of the specimens extracted from mosses and lichens collected during the period from April 1985 to October 1987. Only the collection sites where were taken the moss and lichen samples which proved to contain tardigrades are shown in Fig. 1. About 19 percent of all samples were positive for Heterotardigrada. The collected moss and lichen can be stored for a long period if allowed to dry slowly in a cool and dry place. At the time of examination, a small handful of moss should be soaked in tap water for about 2-4 hours in case of naturally moist material or up to 24 hours for dry material. This allows the encysted and cryptobiosed individuals to recover to the natural state. For the extraction of the organisms from the plant material the samples were narcotized by 4% acetic acid or 20% ethanol for about 15 minutes. The samples then were agitated to loose any tardigrades from the plant surfaces. Then the plant material was squeezed and removed. The remained wash water was swirled and allowed to settle very briefly, and the supernatant was decanted. This procedure was repeated one or more times to remove the unnecessary heavier soil particles. The wash water then was poured through a fine nylon membrane (45 μ in pore diameter). The specimens on the membrane were washed by water in a beaker and allowed to settle. The supernatant poured off, removed, and the settled specimens were thus obtained usually in an asphyxiated condition, which facilitated sorting the organisms. This was transferred to a petridish and sorted at X50 magnification. Using a micropipet they were moved to distilled water in order to wash the debris on the surface of the animal. The specimens were then fixed in 70% ethanol or 4% neutral formalin, and also could be preserved in 70% ethanol. After fixation the tardigrades were mounted on microscopic slides, and then the coverslip was sealed. The mounting medium used was "Liquido di Faure" (Ramazzotti, 1972) or Hoyer's type medium. Examination and drawing was conducted at X400 or X1000 magnification of microscope. The classification system in the present study was based on that followed by Ramazzotti (1983).

SYSTEMATIC ACCOUNT

Phylum Tardigrada

Class Heterotardigrada Marcus, 1927

Order Echiniscoidea Marcus, 1927

Family Echiniscidae Thulin, 1928

Genus *Echiniscus* Schultze, 1840

1. *Echiniscus baius* Marcus, 1928

(Fig. 2a)

Echiniscus baius Marcus, 1928 (pp. 58-59, fig. 62a), 1929 (pp. 327-328, fig. 164), 1936 (pp. 66-67, fig. 75); Ramazzotti, 1983 (p. 350, fig. 167).

Echiniscus (Echiniscus) baius: Ramazzotti, 1972 (pp. 264-265, fig. 58).

Material examined: 17, Ponghwa, Sep. 1, 1987 (H. S. Kim); 22, Yangsan, June 6, July 26, 1987 (J. H. Park, M. K. Shin, M. O. Song & S. N. Moon); 9, Shinŏsan, Mar. 31, 1987 (S. N. Moon); 13, Chirisan, Sep. 25, 1987 (S. N. Moon); 10, Odaesan, May 14, 1987 (S. N. Moon).

Remarks: A number of individuals were collected from lichens at various habitats of the above

localities. *E. baius* has been reported to distribute in Korea by Marcus (1936), but the collection sites were not specified. The present specimens agree closely well with the description of Marcus (1928, 1929, 1936) and Ramazzotti (1972, 1983) except for some deviation in length of body, the lateral cirri, and in color. This species is reported to be about 100 -155 μ in body length (Ramazzotti, 1983). Our

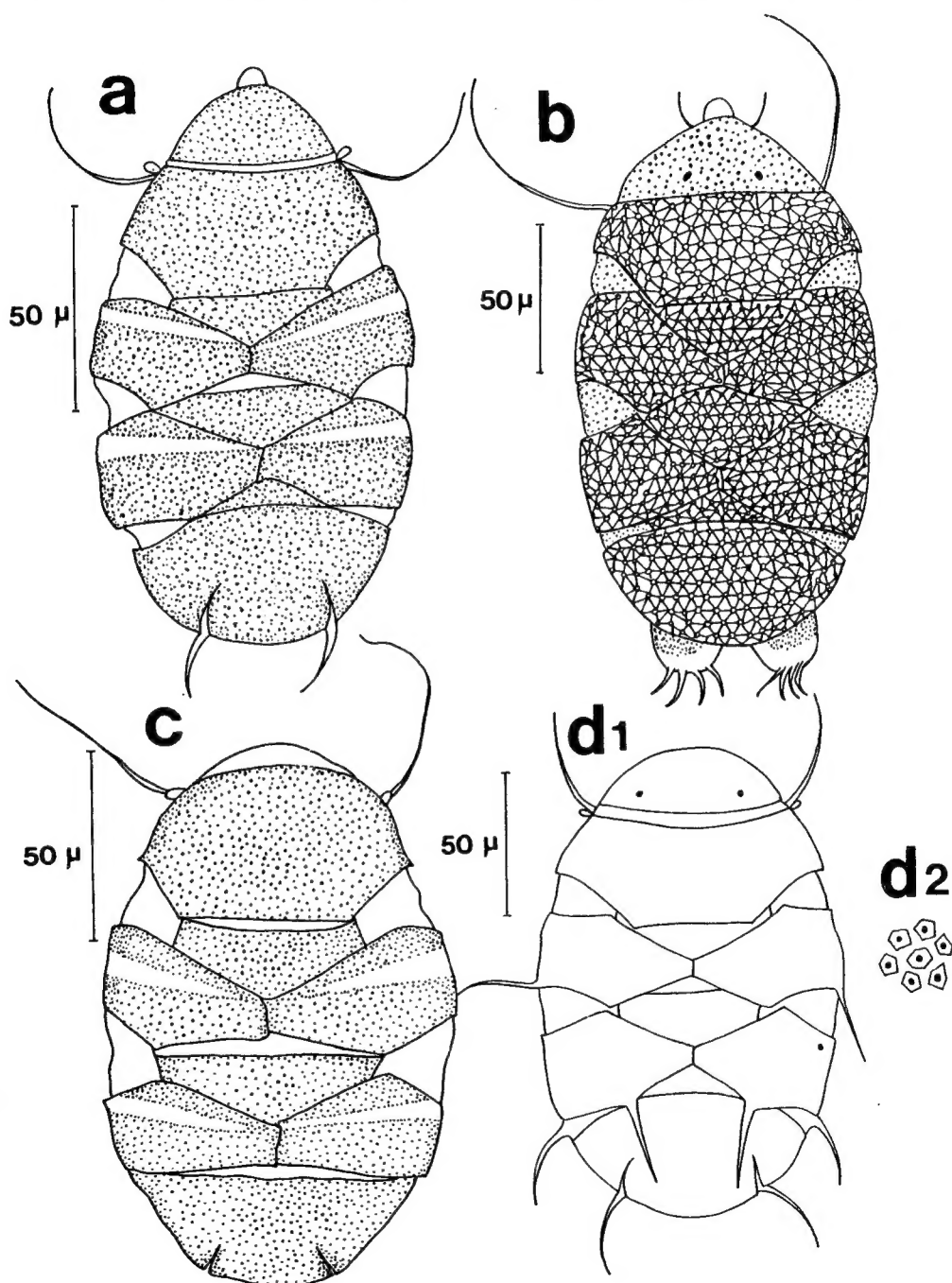


Fig. 2. a, *Echiniscus baius*; b, *E. elegans*; c, *E. kerguelensis*; d1, *E. montanus*; d2, surface pattern of cuticle of *E. montanus*.

specimens ranged from 101–175 μ with a mean of 143 μ . Body colored red or orange while reported to be only red. Cirrus A, for the average-sized animals, was about 40 μ , and cirrus E which is shorter and thicker than cirrus A was about 25 μ . These figures are far beyond, nearly twice, those of 20 μ (cirrus A) and 14 μ (cirrus E) in the mentions of the above investigators. Marcus (1936) also observed some individuals having dorsal spine Dd of about 6 μ , but in the present specimens Dd was not found. Cirrus E often appears bifurcated by his remarks. Other descriptive features are in accordance with those of previous workers: The sculpture is a irregular granulation. Terminal plate with two incisions is not faceted. Light transverse bands devoid of granulation on the paired plate I, II were observed.

2. *Echiniscus elegans* Richters, 1906

(Fig. 2b)

Echiniscus elegans: Marcus, 1928 (pp. 49-50, fig. 50), 1929 (pp. 317-318, fig. 151), 1936 (p. 55, fig. 62); Ramazzotti, 1983 (pp. 382-383, fig. 196).

Echiniscus (Echiniscus) elegans: Ramazzotti, 1972 (pp. 286-287, fig. 82).

Material examined: 31, Odaesan, May 14, 1987 (S. N. Moon); 6, Chirisan, Sep. 25, 1987 (S. N. Moon); 3, Kongju, July 5, 1987 (C. Y. Chang).

Remarks: *E. elegans* is easy to recognize by the sculpture characterized by its reticulate pattern consisting of points densely distributed, connected by short bands. The specimens were collected from lichens together with *Echiniscus montanus*, *E. baius*, *E. kerguelensis*, *Pseudechiniscus suillus* and *Milnesium tardigradum*. This species is reported to be up to 192 μ . In our specimens, most of them were about 160–180 μ ; the smallest 87 μ , the largest 211 μ . Body colored orange. Red eyespots were round or oblong, not always uniform in an individual: right was round, left oblong, or vice versa. Cirrus A, the only lateral appendages, measured about 80 μ on the average-sized animals. The features of terminal plate which has two light incisions and the absence of dentate collar on the fourth pair of legs coincide with the description of Marcus (1936) and Ramazzotti (1983). This species is new to Korea.

3. *Echiniscus kerguelensis* Richters, 1904

(Fig. 2c)

Echiniscus murrayanus Marcus, 1928 (p. 51, fig. 54).

Pseudechiniscus kerguelensis: Marcus, 1928 (p. 108).

Echiniscus kerguelensis: Marcus, 1929 (pp. 320-321, fig. 156); Beasley, 1972 (p. 23, fig. 1); Ramazzotti, 1983 (pp. 393-394, fig. 206).

Echiniscus (Echiniscus) kerguelensis: Ramazzotti, 1972 (pp. 297-298, fig. 92); Morgan and King, 1976 (p. 57, fig. 28).

Material examined: 28, Chirisan, Sep. 25, 1987 (S. N. Moon).

Remarks: The color of this species was reported to be only red by Marcus (1929) and Ramazzotti (1972, 1983), while there are some reports that those of orange-red, pale orange (Morgan & King, 1976), or pale yellow (Beasley, 1972) were also found. The present specimens were all pale yellow. The body length of this species is reported up to 270 μ , with cirrus A about 50–80 μ in length (Ramazzotti, 1983). In our specimens, most of them were about 150–160 μ with a mean of 158 μ : the smallest 120 μ , the largest 168 μ . Cirrus A measured about 41–60 μ . The range of the length variation of the cirrus A in similar size of animals was relatively wide (up to 10 μ) in the specimens examined. Clear transverse bands on the paired plates were not always observed. This species is new to Korea, and was found in lichens with *Echiniscus elegans*.

4. *Echiniscus montanus* Iharos, 1982

(Fig. 2d1, d2)

Echiniscus montanus: Ramazzotti, 1983 (pp. 956-957, fig. 564).

Material examined: 5, Hallasan, Sep. 29, 1986 (K. B. Kwak & M. O. Song); 2, Sögwip'o, Aug. 14, 1985 (S. N. Moon); 7, Odaesan, May 14, 1987 (S. N. Moon).

Description: Most specimens about 140 μ ; the smallest 106 μ , the largest 150 μ . Body colored orange. Red eyespots. Sculpture consisting of polygonal pores distinctly largest on scapular and terminal plates. Paired plates and the second median plate heavily textured caudally, delicate rostrally. Smooth transverse bands on the paired plates present. Third median plate absent. Terminal plate possesses two incisions, and often faceted. Besides of cirrus A, lateral appendages C, D, and dorsal appendage Dd, all filamentous, present. Cirrus B absent. For the average-sized animals, cirrus A, 31-33 μ ; C, 26-28 μ ; D, 23-25 μ ; E, 28-30 μ ; Dd, 27-29 μ . Each of the fourth pair of legs has dentate collar.

Remarks: This species was found in lichens collected from the above sites, and recorded to be also collected from North Korea (Ramazzotti, 1983). From one habitat samples of Hallasan, they were found with *Hypsibius oberhaeuseri*. Of the specimens examined, five individuals with faceted terminal plates were found, while this species was described not to be faceted in its terminal plate (Ramazzotti, 1983).

5. *Echiniscus perviridis* Ramazzotti, 1959

(Fig. 3a)

Echiniscus (Echiniscus) perviridis: Ramazzotti, 1972 (pp. 329-330, fig. 123).*Echiniscus perviridis*: 1983 (pp. 434-436, fig. 240).

Material examined: 2, Taep'o (Cheju I.), Aug. 13-14, 1985 (S. N. Moon); 5, Hallasan, Aug. 14, 1985 (S. N. Moon); 1, Seoul Nat'l Univ., June 9, 1986 (S. N. Moon); 1, Sökraksan, Aug. 29, 1986 (M. O. Song & G. S. Min); 3, Sögwip'o, Feb. 11, 1987 (S. N. Moon).

Description: Most specimens about 220-250 μ ; the smallest 158 μ , the largest 270 μ . Body colored green, often appears very dark green near to black in the edges of the sculptures. Sculptures consisting of a prominent large granules each of which is a collection of very small granules seen at a higher focusing. Granulation appears larger and colored darker on the scapular, terminal, first median and caudal half of the paired plate I, II and the second median plate; small and lighter colored on the rostral half of the paired plate I, II and the second median plate. The texture situated more deeply can only be seen at a high magnification. Light median transverse bands on the paired plates present. Third median plate not delimited laterally. Terminal plate possesses two incisions, but not faceted. Cirrus A characteristically very long (about 145 μ on an individual of 265 μ). Other lateral and dorsal appendages all absent. A papillus and dentate collar with delicate granulation present on each of the fourth pair of legs.

Remarks: This species is new to Korea, and was found both in moss and lichen.

6. *Echiniscus reticulatus* J. Murray, 1905

(Fig. 3b)

Echiniscus reticulatus J. Murray, 1905 (p. 684, Pl. I, figs 4a-4c); Marcus, 1928 (p. 50, fig. 51), 1929 (p. 318, fig. 153), 1936 (pp. 55-56, fig. 63); Cuénot, 1932 (p. 41); Ramazzotti, 1983 (pp. 449-450, fig. 252).

Echiniscus (Echiniscus) reticulatus: Ramazzotti, 1972 (pp. 342-343, fig. 135); Morgan and King, 1976 (p. 64, fig. 35).

Material examined: 5, Ponghwa, Sep. 1, 1987 (H. S. Kim); 11, Chirisan, Sep. 25, 1987 (S. N. Moon).

Remarks: *E. reticulatus* is well characterized by the sculpture consisting of regular hexagons or circles with slightly raised margins, thus appearing as a reticular pattern. Body length ranged from

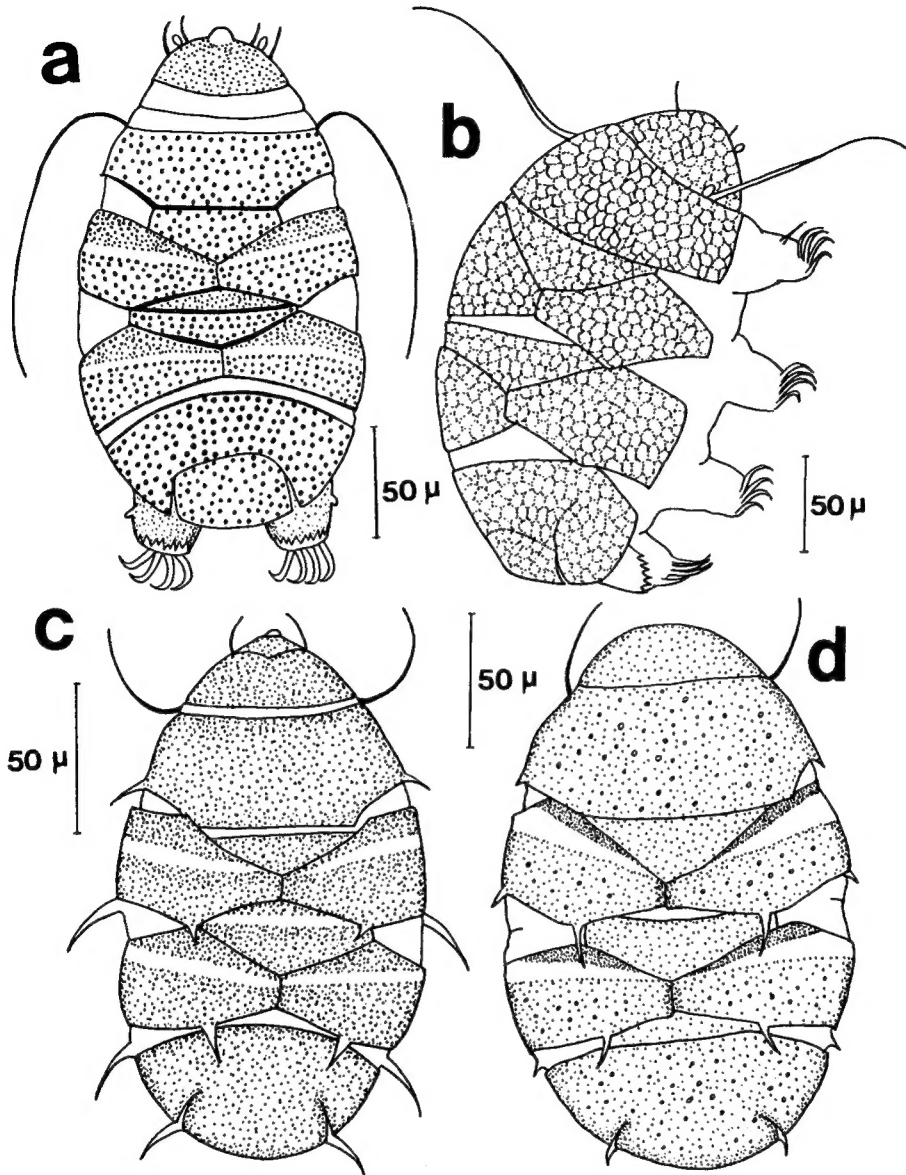


Fig. 3. a, *Echiniscus perviridis*; b, *E. reticulatus*; c, *E. spiniger*; d, *E. spinulosus*.

125-273 μ , but most specimens were about 220-250 μ . *E. reticulatus* was found in lichens together with *Echiniscus baius*, *E. spinulosus*, *Pseudechiniscus suillus*, *P. facettalis*, *Milnesium tardigradum*, and also reported to be found in submerged moss. This species is new to Korea.

7. *Echiniscus spiniger* Richters, 1904

(Fig. 3c)

Echiniscus spiniger: Marcus, 1928 (pp. 60-61, fig. 67), 1929 (p. 331, fig. 169), 1936 (p. 70, fig. 81); Argue, 1972 (pp. 87-88, figs. 1-3); Ramazzotti, 1983 (pp. 460-461, fig. 262).

Echiniscus (Echiniscus) spiniger: Ramazzotti, 1972 (pp. 354-355, fig. 146).

Material examined: 14, Hallasan, Feb. 11, 1987 (S. N. Moon).

Description: Most specimens about 167 μ with a mean of 163 μ ; the smallest 154 μ , the largest 170 μ .

Body colored orange. Sculpture consisting of a fine granulation, especially marked larger on scapular and terminal plates. Paired plate I, II, and the second median plate heavily marked caudally, delicate rostrally. Often light transverse bands devoid of granulation on the paired plates present. Third median plate absent. Terminal plate possesses two incisions. Cirrus A measured about 33μ on an individual of 167μ long. Spines present at lateral positions B, C, D, E, and dorsal positions Cd and Dd. Of the specimens examined, five lacked an appendages at position B, and one lacked both Cd and Dd. For the average-sized animals, the lengths of spines are: B, $10-12\mu$; C and D, $20-22\mu$; E, $19-24\mu$; Cd, $3-6\mu$; Dd, $13-15\mu$. Appendage E, shorter than A, spinous, while A always filamentous.

Remarks: This species resembles *E. spinulosus* in plate markings and the presence of lateral appendages B, C, D, E, and dorsal appendages Cd and Dd, but in *E. spinulosus* the lateral appendages are smaller and shorter than dorsal appendages while they are longer than dorsal one in *E. spiniger*. Both species have some length variation in the appendages of Cd and Dd. The specimens were found in lichen on the bark of trees with *Hypsibius oberhaeuseri*. This species is new to Korea.

8. *Echiniscus spinulosus* (Doyère, 1940)

(Fig. 3d)

Emydium spinulosum Doyère, 1840 (cited from Marcus, 1928)

Echiniscus spinulosus: Marcus, 1928 (p. 60, fig. 66), 1929 (p. 330, fig. 168), 1936 (pp. 69-70, fig. 80); Cuénot, 1932 (pp. 41-42, fig. 22); Ramazzotti, 1983 (pp. 462-463, fig. 264).

Echiniscus (Echiniscus) spinulosus: Ramazzotti, 1972 (pp. 356-357, fig. 148); Morgan and King, 1976 (p. 65, fig. 36).

Material examined: 48, Yangsan, June 6, July 26, 1987 (J. H. Park, M. K. Shin, M. O. Song & S. N. Moon); 25, Shinösan, Mar. 31, 1987 (S. N. Moon).

Description: Most specimens about $240-260\mu$ with a mean of 214μ ; the smallest 110μ , the largest 293μ . Body colored orange or red. Sculpture consisting of a fine to coarse, irregular granulation which is usually absent from the caudal margin of cephalic plate. Transverse bands devoid of granulation clearly observed. Third median plate absent. Terminal plate has incisions and often faceted (about 30% of the individuals examined had faceted terminal plates). Very short spines found at positions of B (often absent), C, D, E. It is reported that appendages C, D, or E may be absent (Ramazzotti, 1983), while our samples all had of the appendages. Short dorsal appendages Cd and Dd present, the lengths of which are somewhat variable. For the average-sized animals, cirrus A was about 45μ ; Cd, 15μ ; Dd, 10μ . Of the specimens examined, one lacked right Cd, and possessed bifurcated left Cd. The first pair of legs with a small spine and the fourth pair with a papillus and dentate collar.

Remarks: A number of individuals were found in lichens. They were present together with *Echiniscus baius*, *Pseudechiniscus suillus*, *P. facettalis* and *Milnesium tardigradum*. Some length variation of A, Cd, Dd and E (up to 2μ) was found. This species is new to Korea.

Genus *Pseudechiniscus* Thulin, 1911

9. *Pseudechiniscus facettalis* Petersen, 1951

(Fig. 4a)

Pseudechiniscus suillus forma *facettalis* Petersen, 1951 (pp. 44-46, fig. 10); Schuster, 1971 (p. 216, fig. 10); Ramazzotti, 1972 (pp. 656-657, fig. 446).

Pseudechiniscus pseudoconifer forma *facettalis* Maucci, 1954 (cited from Ramazzotti, 1983).

Pseudechiniscus facettalis: Ramazzotti, 1983 (p. 871, fig. 584).

Material examined: 15, Ponghwa, Sep. 1, 1987 (H. S. Kim); 5, P'algongsan, Aug. 19, 1987 (M. O. Song); 5, Chirisan, Sep. 25, 1987 (S. N. Moon); 16, Yangsan, June 6, 1987 (J. H. Park, M. K. Shin,

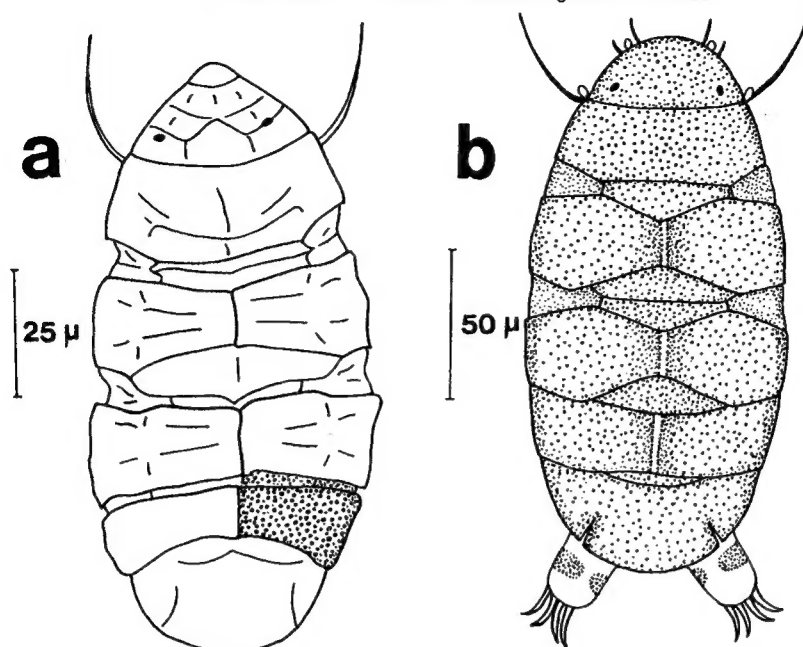


Fig. 4. a, *Pseudechiniscus facettalis*; b, *P. suillus*.

M. O. Song & S. N. Moon).

Description: Most specimens about 145μ with a mean of 138μ ; the smallest 115μ , the largest 168μ . Body colored orange or red. Long, slender bodies with black and oblong eyespots. Sculpture consisting of a regular, fine granulation marked larger on the scapular plate, paired plate I, II, pseudosegmental and terminal plate. Paired plates and the pseudosegmental plate may be divided by a sculptureless stripe in the median line, but not always distinct. Shoulder plate has transversal and longitudinal folds. Distinctly faceted frontal plate and terminal plate. Paired plates often has facetting. Terminal plate has two incisions. Cirrus A about 25μ long in average-sized animals. Other lateral and dorsal appendages absent.

Remarks: The chief distinction of this species from *Pseudechiniscus suillus* is the facetting on the sculptures, and the facetting may be blurred if the animal is squeezed by the cover glass. This species is new to Korea, and was found abundant in lichen together with *Echiniscus reticulatus*, *E. baius*, *E. spinulosus*, *Pseudechiniscus suillus* and *Milnesium tardigradum*.

10. *Pseudechiniscus suillus* (Ehrenberg, 1853)

(Fig. 4b)

Echiniscus suillus: Murray, 1911 (pp. 90-91).

Echiniscus mutabilis Murray, 1905 (p. 683, Pl. I, Figs. 2a-2d), 1906 (p. 27), 1907 (p. 269).

Pseudechiniscus suillus: Murray, 1913 (p. 138); Marcus, 1928 (pp. 107-109, fig. 123), 1929 (pp. 338-390, fig. 230b), 1936 (pp. 129-132, fig. 142); Cuénot, 1932 (pp. 38-39, fig. 20); Argue, 1971 (p. 405, fig. 4); Ramazzotti, 1972 (pp. 654-656, fig. 445), 1983 (pp. 894-896, fig. 605); Morgan and King, 1976 (p. 52, fig. 23); Morgan, 1976 (p. 624 p. 626).

Material examined: 2, Hallasan, Sep. 29, 1986 (K. B. Kwak & M. O. Song); Woraksan, June 8, 1986 (S. N. Moon); 1, Chông-up, July 23, 1986 (M. K. Shin); 16, Odaesan, May 14, 1987 (S. N. Moon); 10, Yangsan, June 6, July 26, 1987 (J. H. Park, M. K. Shin, M. O. Song & S. N. Moon); 12, Chirisan, Sep. 25, 1987 (S. N. Moon).

Description: Specimens about $101\text{--}205\mu$ with a mean of 142μ . Body colored orange to red. Black

eyespots slightly oblong. Cuticular plates finely sculptured with a covering of fine granulation, extending to the interplate regions. Legs are slender with a small patch of fine granulation on the superior basal portion of each. The pseudosegmental plate situated anterior to the terminal plate has a median longitudinal band devoid of granulation. This band also occurring on the first and the second paired plates. Delineation of all the plates often very indistinct. Terminal plate has two incisions, but not faceted. Cirrus A was about 26-30 μ for the average-sized animals. Other lateral or dorsal appendages absent.

Remarks: *P. suillus* was found both in moss and lichen, and present mostly with *Echiniscus baius* and *Pseudechiniscus facettalis*. This species is new to Korea.

ABSTRACT

Ten species of terrestrial Heterotardigrada found in Korea are described, of which *Echiniscus baius* and *E. montanus* are known species, and *Echiniscus baius*, *E. elegans*, *E. kerguelensis*, *E. perviridis*, *E. reticulatus*, *E. spiniger*, *E. spinulosus*, *Pseudechiniscus facettalis* and *P. suillus* are new to Korea.

REFERENCES

- Argue, C. W., 1971. Some terrestrial tardigrades from New Brunswick, Canada. *Can. J. Zool.*, **49**, 3: 401-405.
- Argue, C. W., 1972. Tardigrades from New Brunswick, Canada, 2. *Can. J. Zool.*, **50**, 1: 87-94.
- Beasley, C. W., 1972. Some tardigrades from Mexico. *The Southern Naturalist*, **17**, 1: 21-29.
- Cuénot, L., 1932. Tardigrades. *Faune de France*, **24**: 1-96.
- Marcus, E., 1928. Bartierchen (Tardigrada). *Die Tierwelt Deutschlands*, **12**: 1-230.
- Marcus, E., 1929. Tardigrada. *Klassen und Ordnungen des Tierreichs*, **5**, 1-608.
- Marcus, E., 1936. Tardigrada. *Das Tierreich*, **66**: 1-340.
- Morgan, C. I., 1976. Studies on the British tardigrade fauna. Some zoogeographical and ecological notes. *J. Nat. Hist.*, **10**: 607-632.
- Morgan, C. I. and P. E. King, 1976. Synopsis of the British fauna (New Series). *British Tardigrada*. Linnean Soc., London, **9**: 1-133.
- Murray, J., 1905. The Tardigrada of the Scottish Lochs. *Trans. R. Soc. Edinb.*, **45**: 323-334.
- Murray, J., 1906. Scottish Alpine Tardigrada. *Trans. R. Soc. Edinb.*, **57**: 25-30.
- Murray, J., 1907. Some Tardigrada of the Sikkim Himalaya. *Jl. R. Microsc. Soc.*, 1907, **III**: 269-273.
- Murray, J., 1911. Scottish Tardigrada: a review of our present knowledge. *Ann. Scot. Nat. Hist.*, **78**: 88-95.
- Murray, J., 1913. African Tardigrada. *Jl. R. Microsc. Soc.*, 1913, **II**: 136-144.
- Petersen, B., 1951. The Tardigrade fauna of Greenland. A faunistic study with some few ecological remarks. *Meddr. Greenland*. Ed. C. A. Reizels. Copenhagen, pp. 1-94.
- Ramazzotti, G., 1972. II phylum Tardigrada (2nd ed.). *Bull. Mar. Sci.*, **28**: 1-732.
- Ramazzotti, G., 1983. II Phylum Tardigrada (3rd ed.). *Memorie Ist. Ital. Idrobiol.*, **41**: 1-1012.
- Schuster, R. O., 1971. Tardigrada from the Barranca del Cobre, Sinaloa and Chihuahua, Mexico. *Proc. Biol. Soc. Wash.* **84**, 26: 213-224.